

# Key Causes of Variation Orders in Public Construction Projects in South-South Zone of Nigeria: An Explanatory Factor Analysis

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## Abstract

This study investigates the key causes of variation order in public construction projects in the South-South Zone of Nigeria. Primary data obtained from 338 validated questionnaires, administered to stakeholders in the built environment are analysed using mean score and Factor Analysis. The findings reveal that change of plans or scope of work, client's financial difficulties, inadequate working drawings, inadequate project objectives, errors and omissions in design are the key dominant causes of variation orders in public construction projects. Seven components, which include: client-related, contractor/construction-related, consultant-related, organisational-related, resource-related, environmental-related, and innovation-related, were extracted through factor analysis indicating principal actors and origin of variation orders. It is recommended that stakeholders should give adequate priority not only to the dominant causes of variation orders at planning and implementation stages but also to the principal actors and sources of the causes in order to strategically address the situation and minimize impact of its occurrence.

**Keywords:** Classification, Construction project, Principal actors, South-South zone, Variation order.

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## 1. Introduction

Construction projects are dynamic in nature. Changes are consistently inevitable in the project lifecycle especially at the production stage. This is as a result of clarity of project plans and certainty of assumptions and design variables adopted early at the planning stage which become more obvious to the design team during construction. The unique nature of the industry is characterized with change, that is, transformation of project inputs (materials, labour and machine) to outputs (houses, bridges, culverts). Obviously, construction project can hardly commence from inception to completion without experiencing a change which may ultimately end up as a variation order. The mere fact that the standard practice in construction contracts allows the owner the right to make changes in the work after the contract has been signed and during the construction stage through provision of variation clauses (Ssegawa *et al.* 2002; Fisk and Reynolds 2015) underscores the fact that change in the project is inevitable. Ijaola & Iyagba (2012) argue that the complex nature of construction process is a reason for changes which may consequently lead to a variation order. Alsuliman *et al.* (2012) supporting this assertion, submit that the nature of the industry itself is complicated and uncertain due to the unique features and conditions of each project, with a large number of interdependent and sequential tasks. This variability in construction terms is generally referred to as variation orders (Halwatura & Ranasinghe 2013).

There are different schools of thought concerning the subject of variation order. According to Jadhav & Bhurud (2015) variation order is one of the unfortunate conditions that disturb the flow of construction process and simultaneously delay construction project. Msallam *et al.* (2015) conclude that variation order is a destructive and unpleasant event in a project because of their impact on cost and completion date of project. However, the authors view that variation orders are not necessarily detrimental to the success of a project but could also be beneficial in some situations. Beneficial variations according to Arain & Low (2005) are those that actually help to reduce cost, schedule or degree of difficulty in a project. Similarly Arain & Pheng (2005) also support the previous argument with a view that variation orders are beneficial as they can reduce the duration of a construction project or even eliminate unnecessary cost. Another school of thought has it that some variation orders are predictable, as such; the impact of such can be reduced on project success if it is recognized early with immediate and appropriate action taken. It is worth mention that the occurrence of variation orders can arise at any stage of a project lifecycle but preferably if it occurs and is detected at the initial stage, its associated impacts on project objectives can be reduced. Jadhav & Bhurud (2015) on this note also submit that the occurrence and its impact can be easily managed at the initial phases with the understanding that this effort will help to reduce rework and unwarranted interruption during construction thereby enhancing project performance. Investigations of causes and effects of variation from Malaysia, Kuwait, South Africa, Ethiopia, Addis Ababa and Nigeria indicate that variations in construction projects are common in those countries (Memon *et al.* 2014; Alaryan *et al.* 2014; Tadesse, 2009). However, variation orders on construction projects in the developing countries are more pronounced due to many known technical and political reasons.

The Building and Construction Sectors in Nigeria have recorded strong growth with good stand of 12.09% in 2010 as against 11.97% in 2009 reflecting greater investments in both residential and non-residential buildings

and other construction activities (Akinseinde & Awolesi 2015). However, the drop in the overall GDP contribution of the sector of 2.86% in 2010 and 3.16% in 2009 from 3.76% achieved in 2008 was blamed on the low implementation of capital budget by the Federal Government (NPC 2011; Waziri & Bala 2014). Reports equally show that the construction contributed 3.12% to nominal GDP in the third quarter of 2017 higher than the rate of 2.97% it contributed a year earlier but lower than 4.32% contributed in the second Quarter of 2017 (National Bureau of Statistics 2017). This situation among other things has put the industry under pressure to improve its performance and deliver value for money. Several factors have undermined the performance of the industry particularly the issue of variation order in recent times. Variation orders are common in most construction projects in Nigeria especially South-South zone and its effects are generally worrisome. Studies show that the impact of the variation orders could have been mitigated perhaps it occurs at the project planning stage but unfortunately it occurs mostly at the construction stage when any change made on the existing design will inevitably affect the cost components of the project thereby resulting into project delay, claims, disputes among others (Alaryan *et al.* 2014; Arain & Low 2005; Hanna *et al.* 2002). Although some studies have attempted to investigate the causes and effects of variation orders in Nigeria (Mohammed *et al.* 2015; Ijaola & Iyagba 2012), the South-South zone of Nigeria has not been given adequate attention on this subject bearing in mind the peculiar nature of the area and its socio-economic importance to the nation. Being a coastal region of the nation with other obvious challenges such as politics, social, culture and other environmental influences, the study intends to single out the area for investigation on the causes of variation orders in order to suggest possible solutions to its attendant problems. Against this backdrop, the study aims at investigating the factors responsible for variation orders of public construction projects in South-South geo-political zone of Nigeria. To achieve this, the objectives are to identify the key causes and principal actors of variation order in the zone based on the perceptions of stakeholders in the built environment for effective project delivery. This study is significant in that it provides an insight into the key causes of variation orders in public construction projects in South-South zone of Nigeria, the principal actors and origin of variation orders and it also contributes to literature in investigating the causes of variation orders in construction projects.

## **2. The Need for Variation Orders in Construction Projects**

There are evidences from extant literature showing that there is no universal definition of variation orders. According to Fisk (1997) and O'Brien (1998) variation order is a formal document that is used to modify the original contractual agreement which eventually becomes part of the project's documents. Similarly, Clough & Sears (1994) defined variation order as a written order issued to the contractor after execution of the contract by the owner, which authorizes a change in the work or an adjustment in the contract sum or even the contract time. Desai *et al.* (2015) viewed change order in context of project delivery by defining it as a document describing the scope of the change and its impact on both cost and / or time. Variation order is generally defined as deviation, variation, any change or modification by the owner or the owner's representative experienced in any project from base contract or work scope mutually agreed at contracting time (Kaene *et al.* 2010; Alsuliman *et al.* 2012; Jadhav & Bhurud 2015). Variation orders are not limited to time and cost issues but also quality, health and safety of construction project. Variation orders are not just being raised to effect a change in the contract; rather the process must follow some principles before it can be considered as valid. Harbans (2002) outlined the principles which include: 1) it must be considered as an instruction, 2) originate from an authorized individual, and 3) the instruction must make a change and that change must be defined in the contract document. There are several purposes served by variation orders in construction projects. Some of which are highlighted by Fisk (1997): to change contract plans or to specify the method and amount of payment and changes in contract time; to change contract specifications, including changes in payment and contract time that may result from such changes; to effect agreements concerning the order of the work; for administrative purpose, to establish the method of extra work payment and funds for work already stipulated in the contract; to cover adjustments to contract unit prices for overruns and under runs; to effect cost reduction incentive proposal; and to effect payment after settlement of claims.

### **2.1 Causes of Variation Order**

Variation order has continued to increase not only the cost of construction project but has also impacted on other project objectives, resulting to conflict and disagreement among construction team. Studies show that variation orders cannot be completely eliminated from construction project but their occurrence and subsequent waste can be eliminated if their origin and causes are clearly determined (Fisk 1997; Awad 2001). This challenge has attracted the attention of researchers from different parts of the world on the investigation of root causes of variation orders. Alnuami *et al.* (2010) investigated causes, effects, benefits and remedies of change order on public construction project in Oman and found that client additional work, non-availability of construction manuals and procedures, modification to design change, and lack of reference of similar projects are the most important causes. Zawawi *et al.* (2010), in a similar study identified changing of plans by the owners through generating conflicting design

documents or through change in design afterwards as the main cause of change orders. Keane *et al.* (2010) found that conflicts between contract documents, lack of involvement of contractors at design stage, and conflicting project objectives are the strong reasons for change orders on construction projects. Arain & Low (2006) undertook a study on developers' views of potential causes of variation orders for institutional buildings in Singapore and concluded that errors and omission in design, change in specification by owner, design discrepancies, change in specifications by consultant, and noncompliance of design with governmental regulation were the most significant causes of variation orders. Jadhav & Bhirud (2015) also carried out an analysis of causes and effects of change orders on construction projects in Pune and found that owner changes, additional work and modification to prior work, lack of contractor involvement in design stage unrealistic design periods, lack of communication between contractor and the consultants are among the highly ranked causes of change orders. Further review of the available literature on the causes of variation order generated additional factors with the most frequently mentioned in related studies presented in Table 1 for unifying purpose.

**Table 1: Key Causes of Variation Orders in Public Construction Projects in Nigeria**

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		Sources																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
S/N.	Factors causing variation orders	Hanif et al. (2016)	Memon et al. (2014)	Lokhande et al. (2015)	Alaryan et al. (2014)	Desai, et al. (2015)	Onkar et al. (2013)	Ismail et al. (2013)	Muhd et al.(2015)	Tadesse et al. (2009)	Semere et al. (2013)	Enshassi et al. (2010)	Arain et al. (2006)	Yadeta et al. (2016)	Arain et al. (2006)	Sunday (2010)	Halwatura et al. (2013)	Assbeihat et al. (2015)	Arain (2005)	Gokulkarthi et al. (2015)	Priyantha et al. (2011)	Ndihokubwayo, r. (2008)
1	Inadequate working drawings																					
2	Differing site conditions																					
3	Design errors/ change in design																					
4	Change of plans or scope of work																					
5	Errors and omissions in design																					
6	Non conformance or New government regulations																					
7	Lack of historical data																					
8	Unavailability of equipment																					
9	Impediment in prompt decision making process																					
10	Conflicts between contract documents																					
11	Inadequate project objectives																					
12	Financial difficulties																					

13	Lack of judgment and experience																			
14	Change of schedule																			
15	Weather condition																			
16	Technology changes																			
17	Change in material																			
18	Contractor's desired profitability																			
19	Shortage of skill manpower																			
20	Change in specifications																			
21	Lack of strategic planning																			
22	Lack of coordination/communication																			
23	Change in economic conditions																			
24	Health and safety considerations																			
25	Design discrepancies																			
26	Lack of knowledge of available manpower and equipment																			
27	Defective workmanship																			
28	Value engineering																			

## 2.2 Classification of Causes of Variation Orders

Studies have emerged on different classifications of variation orders in construction projects. The essence of the classification is to have a broad knowledge concerning the causes of variation orders especially on issues related to its origin and principal actors. Hsieh *et al.* (2004) carried out a review of change orders on 90 metropolitan public work projects in Taipei, Taiwan and the exercise resulted into two major classifications, i) administrative needs group (stakeholders' needs) which included; change of work rules/regulation, change of decision making authorities, special need for project commission and ownership transfer, and neighbourhoods pleading, and ii) construction or technical group (project peculiarities or characteristics related) which included; planning and design, underground condition, safety considerations, and natural incidents. Assbeih & Sweis (2015) investigated 30 potential performance factors affecting change orders in Jordanian public construction projects. The myriad of change orders identified were grouped into three major categories: input factors (that is, labor, materials, and equipment); internal environment (that is, contractor, owner and consultant) and exogenous factors (i.e., weather and government regulations). Similarly, Sun & Meng (2009) studied taxonomy for change causes and effects in construction projects by exploring literature. Based on the review, the identified factors were classified into three major groups of change order: external causes, organisation causes, and internal causes. Wu *et al.* (2004) analysed 38 change orders on the National Highway construction project and conclude by classifying the factors into 4 groups in terms of who has introduced the change as owner, design consultant, out-site construction unit or external parties. Arain & Low (2006) reviewed 53 factors responsible for variation orders in institutional buildings in Singapore. Considering the origin of the variation orders, the factors were categorized into four major groups i)

owner related factors; ii) consultant related factors; iii) contractor related factors; and iv) other factors. A similar classification of the latter has been observed from other relevant studies worldwide (Sunday 2010; Alnuami *et al.* 2010; Enshassi *et al.* 2010). The current study intends to provide a justification for the classification of variation orders using Factor Analysis which is missing in some previous studies as previously discussed.

### 3. Methodology

The study adopts the exploratory survey design approach that involves the use of structured questionnaire in achieving the objectives of the study. The population of the study consists of organised clients, registered contractors, and professionals (Architects, Builders, Engineers and Quantity Surveyors) involved in the procurement and delivery of public construction projects in South-South zone of Nigeria. The sample frame of 1031 is obtained from the lists of registered contractors from the corporate organisations, state and federal establishments in the respective states while the directories of professionals are also consulted to obtain the list of various professional bodies at their respective state chapter level. Sample size of 533 is taken from sampled population which consists of 160 clients, 229 contractors and 144 consultants (including 43 Architects, 17 Builders, 53 Engineers and 31 Quantity Surveyors) involved in public construction projects is adopted for the study using the Taro Yamane formula as stated by Udofia (2011). The minimum qualification of the respondents is Higher National Diploma (HND) which is also minimum qualification for corporate membership of professional bodies in the Nigerian built environment; 86 per cent have over five years of professional work experience in the industry. A combination of two probabilistic sampling techniques i.e. stratified and systematic sampling techniques is adopted for the study. The stratified sampling technique is to effectively reduce the variability in the population (Adeyanju *et al.* 2008). The use of systematic sampling method is to obtain the list of the sampling unit in a systematic order in such a way that each item in the population is uniquely identified by the order. The causes of variation order adopted in the study are derived from those used in the previous studies to ensure content validity.

The pilot study which involves six research experts in the built environment is conducted in order to evaluate proper understanding of the research questions and to ascertain whether the questionnaire items adequately cover the domain of the construct and important information according to the research objectives of the study. This process assists in eliminating any potential problems of the research instrument and to test the validity and workability of the instrument. Inputs are collated which result to 39 variables shortlisted as variation orders and are adopted in the production of the final questionnaire used in this study. The questionnaire is divided into two sections; the first section elicits information on the demographic characteristics of respondents. Section two contains information on causes of variation orders in public construction projects. The questions in this section are given in a 5-point rating scale (ranging from 1 very low important to 5 very high important) to analyse key causes of variation orders in public construction projects. The questionnaires are self-administered. Three hundred and eighty seven questionnaires were returned in which 49 feedbacks are identified as invalid due to incomplete information. Consequently, 338 valid questionnaires are used for the analysis giving a valid response rate of 63.42%. The percentage is higher than the 20-30% return rate for research conducted within the construction industry therefore, the result of the survey cannot be considered as biased or of little significance (Moses & Stahelski 1999; Akintoye & Fitzgerald 2002). The collected data were checked for completeness and consistency before data processing and analysis.

Data collected are processed using Statistics Package for Social Sciences (SPSS). The analyses were done to rank the different causes of variation orders and to cross- compare the Mean Score (MS) of each item. Mean Score (MS) is used to determine the level of significance of each factor by 5 expressions defined by the intervals 0.8 with 3.4 as a cut-off for high significance based on Kazaz *et al.* (2008). The ranking of the factors is determined based on the mean score of each item which is calculated by the following equation:

$$MS = \frac{\sum_{i=1}^5 (R_i P_i)}{n}, (1 \leq MS \leq 5) \dots \dots \dots \text{Equation (1)}$$

(Where MS = Mean Score,  $R_i P_i$  = Rating point  $i$  (range from 1-5),  
 $R_i$  = response to rating point,  $i$ ) and  $n$  = total responses = summation of  $R_i$  from 1-5

Principal Component Analysis (PCA) test is carried out to reduce the dimension of the key causes of variation orders in the study. According to Abdi & William (2010), PCA is the most popular multivariate statistical technique and it is used by almost all scientific disciplines to extract the important information from observed data based on inter-correlation. For a set of data to be considered suitable for factor analysis, some issues are expected to be clarified. As a result, the issues relating to the adequacy of the sample size for establishing the reliability of factor analysis are addressed by testing Cronbach's alpha, which is commonly used as a measure of internal consistency of how well the item in the set correlate to each other. It is common for researchers to suggest a threshold value of 0.7 (Pallant 2007). Meanwhile, Kaiser-Meyer-Olkin (KMO) and Bartlett's Test are commonly used to measure the sampling adequacy in factor analysis. The KMO index ranges from 0 to 1, with 0.6 suggested as the minimum value for a good factor analysis (Tabachnick & Fidell 2007). Nonetheless, the threshold value of



KMO is advocated to be greater than 0.5 if the sample size is adequate (Child 1990) while Bartlett's Test of Sphericity should be significant ( $p < 0.05$ ) for the factor analysis to be considered appropriate. Yong & Pearce (2013) and Costello & Osborne (2005) opine that the number of factors could be determined based on a threshold eigenvalue of 1, and that a structure loading of  $\geq 0.3$  can be considered strong enough for interpretation.

## 4 Results and Discussion

### 4.1 Evaluation of Key Causes of Variation Orders

This section evaluates the perceptions of the three groups of respondents - client, contractor and consultant of the key causes of variation orders in public construction projects in the South-South zone of Nigeria. The respondents were asked to rate the prevalence of 39 key causes of variation orders resulting from the pilot study involving six research experts. Each factor in this case has a Mean score which is calculated by the formula in equation (1). The results of the evaluation - mean scores, rank positions based on different groups of respondents and the overall rank position of each factor are presented in Table 2.

**Table 2.** Key Factors of Causes Variation Orders in Public Construction Projects

S/n.	Factors	Client		Contractors		Consultants		Combined	
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
1	Change of plans or scope of work	4.65	1st	4.70	1st	4.61	1st	4.65	1st
2	Client's financial difficulties	4.60	3rd	4.67	2nd	4.60	2nd	4.62	2nd
3	Inadequate working drawings	4.53	6th	4.60	4th	4.53	4th	4.55	3th
4	Inadequate project objectives	4.61	2nd	4.58	5th	4.44	7th	4.54	4th
5	Errors and omissions in design	4.56	4th	4.54	6th	4.49	5th	4.53	5th
6	Change in design by consultant	4.49	7th	4.51	7th	4.53	4th	4.51	6th
7	Impediment in prompt decision making process	4.49	7th	4.39	12th	4.56	3rd	4.48	7th
8	Change of schedule by client	4.43	10th	4.61	3rd	4.37	9th	4.47	8th
9	Differing site conditions	4.54	5th	4.47	8th	4.37	9th	4.46	9th
10	Design complexity	4.51	5th	4.47	8th	4.39	8th	4.46	9th
11	Defective workmanship	4.44	9th	4.42	10th	4.46	6th	4.44	10th
12	Change in economic conditions	4.40	10th	4.40	11th	4.39	8th	4.40	12th
13	Contractor's financial difficulties	4.35	12th	4.39	12th	4.42	7th	4.39	11th
14	Design discrepancies	4.46	8th	4.35	16th	4.33	10th	4.38	13th
15	Change in specifications by consultant	4.46	8th	4.39	15th	4.25	13th	4.36	14th
16	Change in design by client	4.33	11th	4.54	6th	4.19	14th	4.36	14th
17	Unforeseen problems	4.37	11th	4.32	17th	4.33	10th	4.34	15th
18	Lack of contractor's involvement in design	4.21	15th	4.46	9th	4.30	11th	4.32	16th
19	Contractor's lack of judgment and experience	4.30	13th	4.35	16th	4.25	13th	4.30	17th
20	Conflicts between contract documents	4.19	14th	4.19	20th	4.28	12th	4.22	17th
21	Change of schedule by contractor	4.18	16th	4.30	18th	4.11	17th	4.19	18th
22	Lack of coordination/communication	4.07	18th	4.32	17th	4.18	15th	4.19	18th
23	Consultant's lack of historical data	4.33	11th	3.82	27th	4.16	16th	4.11	19th
24	Replacement of contractor due to non performance	3.88	23rd	4.05	23rd	4.28	12th	4.07	20th
25	Change in material	4.12	17th	3.81	28th	4.23	14th	4.05	21st
26	Lack of strategic planning	4.00	19th	4.18	21st	3.95	19th	4.04	22nd
27	Lack of consultant's knowledge of available manpower and equipment	3.96	21st	3.98	25th	4.09	18th	4.01	23rd
28	Shortage of skilled manpower	3.89	22nd	4.26	19th	3.79	23rd	3.98	25th
29	Weather condition	3.98	20th	4.04	24th	3.89	21st	3.97	24th
30	Consultant's lack of judgment and experience	4.00	19th	4.04	24th	3.60	25th	3.88	26th
31	Honest wrong belief of consultant	3.42	27th	4.11	22nd	3.91	20th	3.81	26th
32	Health and safety considerations	3.79	24th	3.96	26th	3.63	24th	3.80	28th
33	Poor procurement process	3.77	25th	3.81	28th	3.63	24th	3.74	28th
34	Unavailability of equipment	3.65	26th	3.60	29th	3.82	22nd	3.69	30th
35	Contractor's desired profitability	3.65	26th	3.16	33rd	4.19	14th	3.67	31st
36	Unfamiliarity with local conditions	3.39	28th	3.32	30th	3.25	27th	3.32	32nd
37	Technology changes	3.07	30th	3.47	29th	3.32	26th	3.29	33rd
38	Obstinate nature of client	3.25	28th	3.18	32nd	3.11	29th	3.18	35th
39	Non conformance to new government regulations	3.09	29th	3.21	31st	3.14	28th	3.15	36th

The result in Table 2 shows that the overall rank of the factors ranges as  $3.15 \leq MS \leq 4.65$ , with the most prevalent among the factors being change of plans or scope of work with  $MS = 4.65$ ; the least ranked factor is non conformance to new government regulations with  $MS = 3.15$ . Thirty five of the factors are significant while five of the factors are non-significant as established in the methodology of the study. Based on the overall mean rank,

the first 10 factors that top the list of causes of variation orders are: change of plans or scope of work (MS = 4.65), client's financial difficulties (MS = 4.62), inadequate working drawings (MS = 4.55), inadequate project objectives (MS = 4.53), errors and omissions in design (MS = 4.53), change in design by consultant (MS = 4.51), impediment in prompt decision making process (MS = 4.48), change of schedule by client (MS = 4.47), with differing site conditions and design complexity ranked same (MS = 4.46). Factors that are insignificant based on the analysis include: unfamiliarity with local conditions (MS = 3.32), technology changes (MS = 3.29), obstinate nature of client (MS = 3.18), and non conformance to new government regulations (MS = 3.15).

"Change of plans or scope of work" ranks highest by each of the respondent groups with MS of 4.65, 4.65 and 4.61 by the client, contractor and consultant group respectively. This implies that this factor is a major factor that causes variation orders in the public construction projects in the study area. This could be attributed to the fact that change of plans or scope of work accompanied with time and cost implications invariably affect project objectives. The source of this factor in a project could be as a result of inadequate planning or lack of critical evaluation of client's brief at the project definition stage (Arain *et al.* 2004). The finding is consistent with a previous study conducted by Alaryan *et al.* (2014) and Gokulkarthi & Gowrishankar (2015). However, the result is at variance with Enshassi *et al.* (2010) who rather identify lack of materials and spare parts of equipments as the most important cause of variation orders in construction projects in Gaza Strip though this is attributed to border closure. The analysis further shows that the respondents groups differ in the remaining factors that cause variation orders in construction projects. As a result, the overall ranking positions of the variables are considered for further discussion. The second factor as perceived by all respondents is the "client's financial difficulties" which is critical as non-availability and inadequate fund can affect cash flow as well as halting smooth running of the project. This problem could lead not only to change in work schedules and specifications but will also affect the quality of the construction (Memon *et al.* 2014). The financial difficulties experienced in a project are complicated by high lending rates and high loan requirements by most financial banks and institutions especially in the developing countries. Client's financial issues impact progress of work due to lack of prompt response to payment especially to the contractor on projects practically completed which may eventually lead to variation orders. The finding is consistent with Sweis *et al.* (2014) who found financial difficulties as second leading cause of factors affecting contractor performance on public construction projects.

"Inadequate working drawings" is a consultant related cause of variation order and can be attributed to inability to convey a complete concept of the project design in a clear and concise form (Geok 2002). When client provides limited time and budget for designer to complete the design in order to expedite the bidding process, the result is this factor, that is, inadequate or incomplete drawings. Efforts to resolve this problem among the project team may further cause unpredictable changes which may affect the project in various ways depending on the timing and cost element of the change. Arain *et al.* (2004) view that inadequate working drawing details can result in misinterpretation of the actual requirement of a project and this can affect the project objectives. Sufficient time given to the designers and thorough reviewing of design details would assist in minimizing this problem. This result of the study was in agreement with previous study by Dosumu & Aigbavboa (2018) who found poor working drawing as the major cause of variation on selected building projects in Nigeria. "Inadequate project objectives" is also among the highly significant causes of variation orders as perceived by all respondents with the view that it may further add more complication to the realization of project objectives. Project objective is fundamental to any project; its inadequacy will certainly limit the designer in developing a comprehensive design which could also trigger other cost or time related variation orders during construction phase of the project. This agrees with Koushki *et al.* (2005) who found that variation orders issued during various phases of construction projects negatively affect both the completion time and costs of projects. "Errors and omissions in design" is the fifth overall key cause of variation order based on the result of the analysis. When inadequate time or insufficient detail characterizes a project, production of design within the required time frame may inevitably result to errors and omissions in some cases (Enshassi *et al.* 2016). This supports the previous findings that errors and omissions in design are an important cause of project delays, loss of productivity, rework, cost and time overrun (Arain *et al.* 2004; Hanna & Gunduz 2004). Enshassi *et al.* (2010) were also in agreement with the findings of this study stating that if the errors were not rectified during the design phase they would eventually appear in the construction phase and initiate variations in order to implement corrective measures.

#### 4.2 Principal Component Analysis of Key Causes of Variation Orders

Factor analysis reduces a set of variables into a fewer number of non-correlated factors that can represent the original variables (Fellows & Liu 2008; Iyer & Jha 2005). In order to have a broad knowledge of the causes of variation orders especially in matters relating to their origin and sources, a dimension reduction test was conducted on the responses of the respondents. This helps in finding groups of related variables in a more easily understood framework as origin and principal actors of variation orders (Field 2005). According to Neuman & Kreuger (2003), the fundamental concept underlying factor analysis is the ability to statistically manipulate the empirical relationship among several variables to help reveal hypothetical constructs of the relationships. It is also a means

of condensing information contained in original variables, into a smaller set of dimensions (factors) with minimum information loss (DeCoster 2015). The adequacy of the sample size for establishing the reliability of factor analysis were addressed by testing Cronbach's alpha which was found to be 0.73 for this study. Thus, it is deemed acceptable, since the value of alpha is desirable with the range higher than 0.6 (Hair et al. 2006). The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO-test) indicates that the sample is adequate if the value of KMO is greater than 0.5 (Field 2005). The test result of KMO is 0.527 as presented in Table 3, suggests the adequacy of the sample size for the factor analysis. The Bartlett's test of Sphericity is also significant with  $p = 0.000$ , suggesting that the population is not an identity matrix (Wai et al. 2013).

**Table 3.** KMO and Bartlett's Test

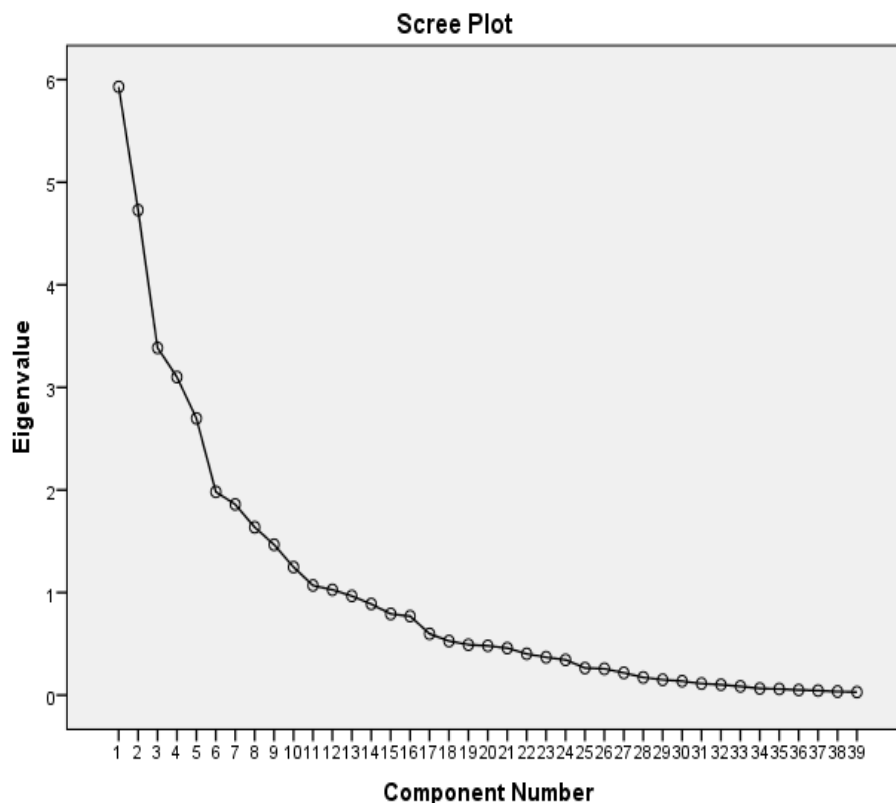
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.527
Bartlett's Test of Sphericity	Approx. Chi-Square	1398.508
	df	741
	Sig.	0.0000

Data is later subjected to principal component analysis (with Varimax rotation) after the KMO sampling adequacy and Bartlett's tests of Sphericity are conducted. Applying the latent root criterion, seven components which recorded eigenvalues above 1, were extracted as presented in Table 4. These seven components explain a total of 60.732 per cent of the variance (see cumulative column) which is greater than the threshold of 50% total variance explained as suggested by Pallant (2007) and also from the Scree Plot in Figure 1.

**Table 4.** Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	% of			% of			% of		
	Total	Variance	Cumulative %	Total	Variance	Cumulative %	Total	Variance	Cumulative %
1	5.931	15.208	15.208	5.931	15.208	15.208	4.746	12.168	12.168
2	4.729	12.125	27.333	4.729	12.125	27.333	4.219	10.818	22.986
3	3.385	8.681	36.014	3.385	8.681	36.014	3.839	9.844	32.830
4	3.101	7.951	43.964	3.101	7.951	43.964	3.664	9.395	42.226
5	2.699	6.919	50.884	2.699	6.919	50.884	2.745	7.038	49.264
6	1.982	5.082	55.965	1.982	5.082	55.965	2.319	5.946	55.209
7	1.859	4.767	60.732	1.859	4.767	60.732	2.154	5.523	60.732

Extraction Method: Principal Component Analysis.



**Figure 1:** Scree Plot



**Table 5. Key Causes of Variation Orders in Groups**

Key Causes of Variation Orders		Components						
		1	2	3	4	5	6	7
<b>A</b>	<b>Client-related</b>							
1	Client's financial difficulties	.768						
2	Change in design by client	.766						
3	Obstinate nature of client	.717						
4	Impediment in prompt decision making process	.689						
5	Change of plans or scope of work by client	.682						
6	Change of schedule by client	.610						
7	Inadequate project objectives	.602						
8	Poor procurement process	.552						
<b>B</b>	<b>Contractor/Construction-related</b>							
9	Unfamiliarity with local conditions		.770					
10	Lack of contractor's involvement in design		-.752					
11	Change of schedule by contractor		-.693					
12	Contractor's desired profitability		.557					
13	Differing site conditions		-.543					
14	Contractor's lack of judgment and experience		.541					
15	Defective workmanship		.486					
16	Contractor's financial difficulties		-.483					
17	Replacement of contractor due to non performance		.556					
<b>C</b>	<b>Consultant-related</b>							
18	Consultant's lack of judgment and experience			.761				
19	Design complexity			.687				
20	Honest wrong belief of consultant			.612				
21	Change in specifications by consultant			-.592				
22	Change in design by consultant			.590				
23	Errors and omissions in design			.528				
24	Design discrepancies			.475				
25	Inadequate working drawings			.417				
26	Conflicts between contract documents			-.353				
<b>D</b>	<b>Organisational-related</b>							
27	Health and safety considerations				-.720			
28	Poor communication structure				.636			
29	Non conformance or New government regulations				.583			
<b>E</b>	<b>Resource-related</b>							
30	Unavailability of equipment					.842		
31	Lack of historical data					.710		
32	Lack of knowledge of available manpower and equipment					.702		
33	Shortage of skill manpower						-.569	
<b>F</b>	<b>Environmental-related</b>							
34	Weather condition						.676	
35	Change in economic conditions						.567	
36	Unforeseen problems						.563	
<b>G</b>	<b>Innovation-related</b>							
37	Change in material							.527
38	Lack of strategic planning							.837
39	Change in technology							.564

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.  
a. Rotation converged in 13 iterations.

Following the examination of inherent relationships among those variables under each component, the total variance explained by each component extracted as presented in Table 5 is as follows: The first principal component accounts for 12.17% of the total variance, the second component explains 10.12%, the third component explains 9.84%, the fourth component explains 9.402%, whilst Component 5, 6 and 7 accounts for 7.04%, 5.95% and 5.52% of the variance respectively. Eight variables were loaded into Component 1 and seem to address client-related causes. The component is therefore labelled, "client-related" since the underlying issues could be attributed to project client. The findings of this study align with several previous studies in different parts of the world

including Sunday (2010); Alnuami *et al.* (2010); Enshassi *et al.* (2010), who classify similar factors as client-related both in road and building projects. Nine variables are found loaded to Component 2 which appear to address, "contractor and project characteristics related causes" as the nine identified variables associated to the contractors and other issues peculiar to project. The Component is therefore labelled "contractor/construction-related causes". The findings also agree with that of Hsieh *et al.* (2004), who finds similar issues, under this component as construction (or project peculiarities) related factors while Alnuami *et al.* (2010); Enshassi *et al.* (2010); Oyewobi *et al.* (2016) classify it as contractor-related.

Nine variables are also found loaded into Component 3 attributed to project consultants particularly the designers. This is because identified variables could be addressed viewed from the consultant's end. On this basis the component is thus labelled, "consultant-related" causes of variation order. The result is in line with the findings of Arain & Al-Race (2010); Oyewobi *et al.* (2016) who group the concerned issues in similar studies as consultant-related causes of variation order. Component 4 is loaded with three variables strongly addressing organizational related issues both within and outside project organization. Every construction organization has minimum standard for health and safety considerations. Organisational structure in each establishment sets a standard for effective communication in addition to strict adherence to government regulations particularly for a new project. Deviation from any of these could constitute a severe source of variation order. Since this component has sufficiently addressed issues concerning organisation, it is therefore labelled "organisational-related". The result is in line with the findings of Sun & Meng (2009) whose study on taxonomy for change causes in construction projects classifies the factors into three major groups of change order: external causes, organisation causes, and internal causes.

Four variables are strongly loaded into Component 5 which seems to adequately address project resource causes. As a result of this, the component is labelled, "resource-related" causes. This is in line with the previous research of Assbeih & Sweis (2015) whose evaluation of similar issues considered in this component are classified as input factors, that is, labour, materials, and equipment. Studies show that various resources factors affect cost management and have resulted to significant amount of cost overrun worldwide (Rahman *et al.* (2013). Component 6 strongly loaded with three variables jointly address environmental factors that are particularly external to the project. On this basis, component 6 is labelled "environmental-related" causes of variation orders. Lastly, three variables are loaded into Component 7 which can be attributed to innovative concept. The component was as a result labelled "innovation-related" causes of variation order. Innovation involves firm's acceptance and adoption of new ideas which is a critical strategy to meet the needs of modern day clients in given value for their hard earned income. Failure to meet or change to adopt necessary innovative ideas at the construction stage would result to issuing variation orders and other associated implications.

## 5. Conclusion and Recommendations

The study investigates the key causes of variation orders in public construction projects in the South-South zone of Nigeria. Based on the findings of the study, the conclusion drawn is that variation orders in construction project is not inevitable; consequently, stakeholders in the industry should be aware and develop a template for evaluation of variation orders particularly at planning and implementation stages of construction project. Thirty nine key causes of variation orders are adopted in the study as characterized by construction projects in the study area based on the literature review and pilot survey. The ten dominant among the causes are: "change of plans or scope of work", "client's financial difficulties", "inadequate working drawings", "inadequate project objectives", "errors and omissions in design", "change in design by consultant", "impediment in prompt decision making process", "change of schedule by client", "differing site conditions", and "design complexity". Seven components are extracted through factor analysis in order to have a broad knowledge of the principal actors and origin of variation order. These include: client-related, contractor/construction-related, consultant-related, organisational-related, resource-related, environmental-related, and innovation-related. It is recommended that apart from significant causes of variation orders identified in this study, stakeholders should also give adequate priority to the principal actors and origin of the causes in order to strategically address the situation and minimize the impact of its occurrence. The study further recommends inclusion of variation orders management (VOM) plan as part of project requirements in order to meet the needs of the client.

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